Comparing radiative transfer model-based LAI retrieval with in-situ observations and mechanistic modelling for grassland growth assessment

Daria Larcher[1,2], Sélène Ledain[2], Helge Aasen[2]

EOA Earth Observation of Agroecosystems team

www.eoa-team.net

Objective

Develop a method to estimate grass growth using satellite data time series along with an RTM inversion-based LAI retrieval approach.

Introduction

Grasslands cover a significant portion of Switzerland's landscape, primarily serving for livestock production, but also providing many ecosystem services. Through exposure to climate change and intensive land use such as frequent mowing and intensive grazing grasslands are increasingly threatened. To evaluate the state of grasslands and optimize sustainable management practices, it is necessary to understand their ecological state, the management strategies and use intensity they're exposed to. Satellite data provide a cost effective alternative to the acquisition of ground-field data, to analyse grassland on a larger scale.

This poster discusses Enhanced Vegetation Index (EVI) time series from Sentinel-2 images and the comparison to in-situ observations and mechanistically modelled Leave Area Index (LAI).

Workflow to generate EVI curves from Sentinel-2 images

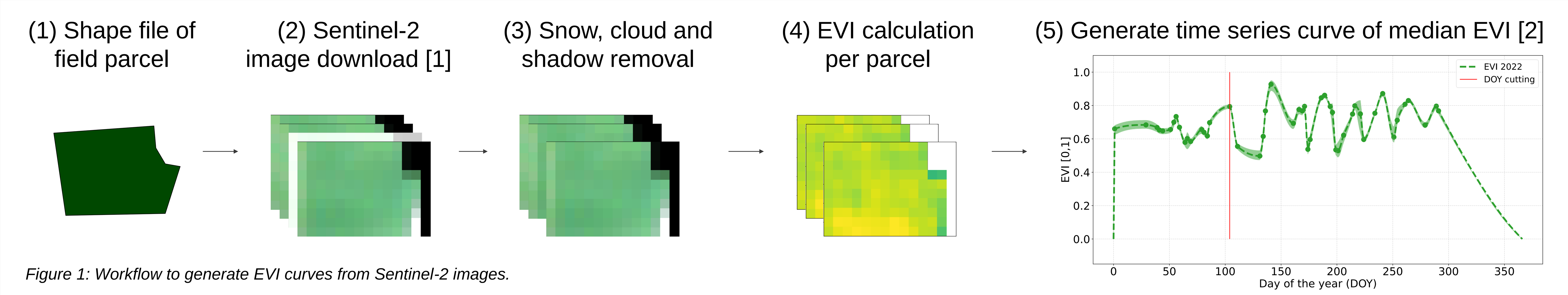

Figure 1: Workflow to generate EVI curves from Sentinel-2 images.

Main challenges:

- (1) Field parcel shape and its translation to Sentinel-2 pixel grid: *exclude adjacent pixels with other surface types*
- (3) Snow, cloud and shadow removal based on Sentinel-2 Scene Classification Layer (SCL): *exclude falsely classified vegetation pixel*

Comparison to in-situ biomass observations

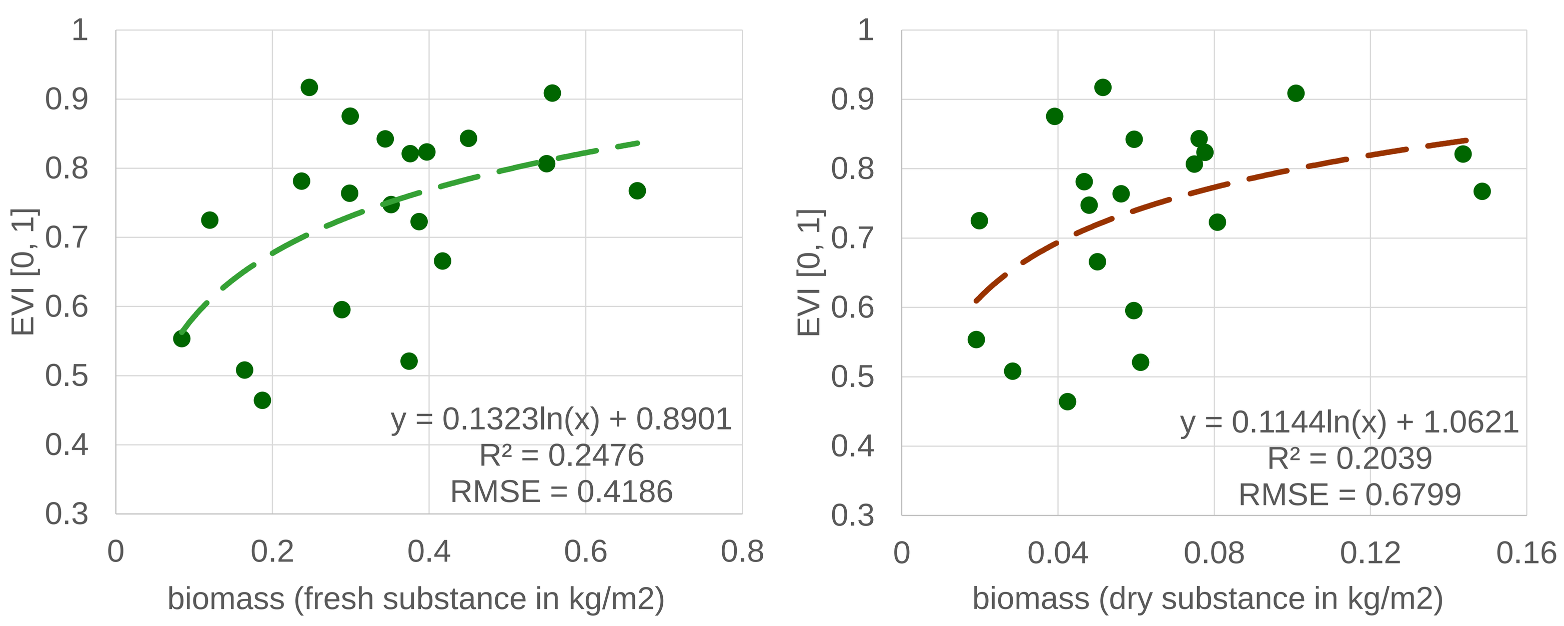

Figure 2: Scatter plots showing the correlation between satellite derived EVI and ground truths biomass (fresh and dry substance, N = 20). The logarithmic regression model showed the strongest correlation.

RMSE and R^2 do not capture the entirety of the relationship. Both data sets show a large spread of values and have their limitations:

- EVI:
  - Small parcel size: mixed signal in Sentinel-2 pixels at 10 m resolution
- Biomass:
  - Unclear location of some parcels
  - Extent of parcels are unclear
  - Grass length shows great variation within a single parcel
  - Reference area on which the grass was harvested is relatively small

Looking for grassland biomass data!
Do you have or know about any georeferenced biomass data of grasslands that would like to be analysed?
Get in touch!

Conclusion:

Literature suggests that biomass can reliably be estimated from satellite derived EVI [3], however, prerequisite to confirm this are reliable EVI and biomass data.

Outlook: Comparison to LAI from RTM

Next steps include the comparison of the satellite derived EVI curves to Radiative Transfer Model (RTM) derived LAI values. A better correlation is expected as the RTM takes into account the full Sentinel spectrum compared to the EVI which only includes 3 of the 12 bands.

Comparison to mechanistically modelled LAI

The mechanistical model ModVege [5] which is based on a set of meteorological variables (temperature, solar radiation, precipitation, soil characteristics) at daily resolution as well as cutting dates, has been used to model LAI under different management intensities.

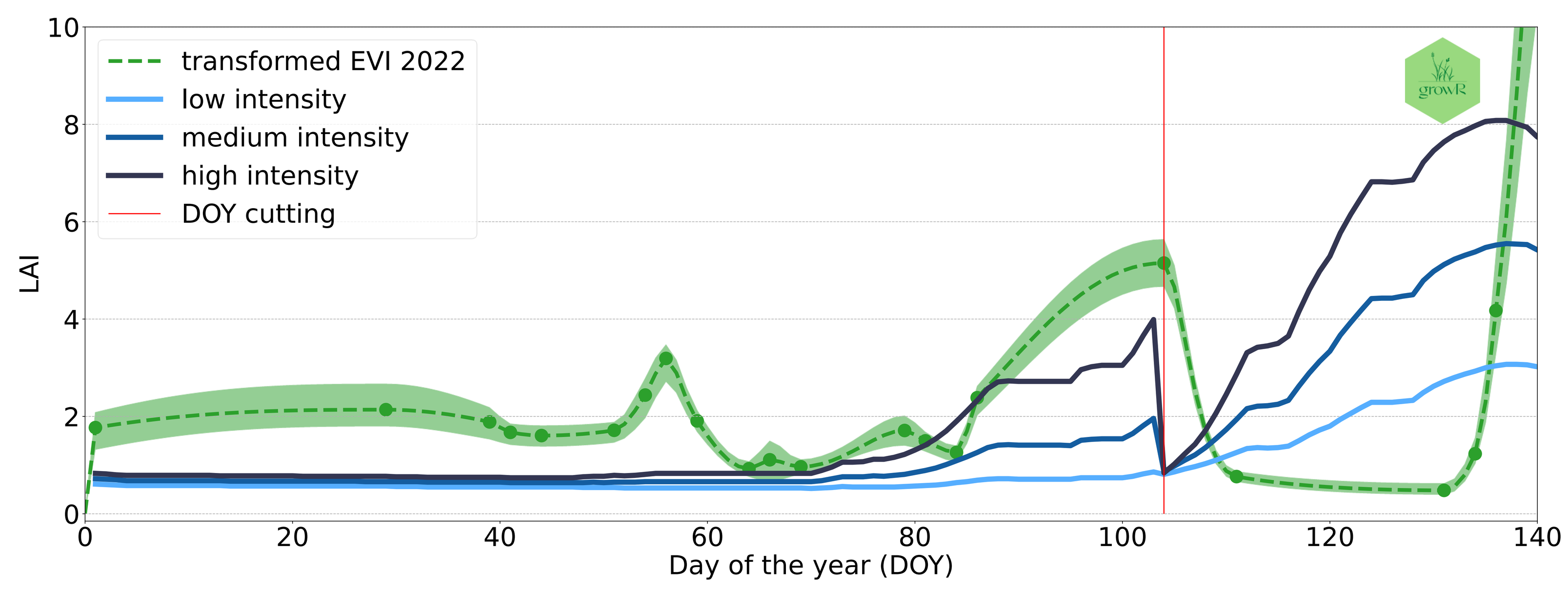

Figure 3: Transformed EVI and modelled LAI at different management intensities of the growth period including the first cutting. To directly compare the EVI with the modelled LAI, the EVI data has been transformed based on the logistic relationship of vegetation indices with LAI [4].

- DOY 0 - 80:
  relatively low LAI
- DOY 80 - 100:
  increasing LAI
  - LAI: *first stagnation, then increase again* ⟶ *meteorological parameters seem to have limited growth* ⟶ *possibly snow, overcast or drop in temperature*
  - EVI: *steady increase, but little data points* ⟶ *possibly snow or overcast*
- DOY 100 - 120:
  decrease in LAI after cut / grazing
  - LAI: *immediate increases after cutting*
  - EVI: *stays low until DOY 130* ⟶ *satellite captures length of grazing period*

Conclusion:

The two methods can be regarded as complementary. Satellite data is depicting real changes in biomass availability, however at a relatively coarse temporal resolution. The modelled data is estimating grass growth based on an ensemble of variables, providing information for periods without satellite acquisitions.

References

[1] Graf, L. V., Perich, G. & Aasen, H. EOdal: An open-source Python package for large-scale agroecological research using Earth Observation and gridded environmental data. *Computers and Electronics in Agriculture* **203**, 107487 (2022).
[2] Oriani, F., Aasen, H. & Schneider, M. K. Different growth response of mountain rangeland habitats to annual weather fluctuations. (2024).
[3] Guerini Filho, M., Kuplich, T. M. & Quadros, F. L. F. D. Estimating natural grassland biomass by vegetation indices using Sentinel 2 remote sensing data. International Journal of Remote Sensing 41, 2861–2876 (2020).
[4] Carlson, T. N. & Ripley, D. A. On the relation between NDVI, fractional vegetation cover, and leaf area index. Remote Sensing of Environment 62, 241–252 (1997).
[5] Kramer, K. P. & Calanca, P. growR: R Implementation of the Vegetation Model ModVege. Journal of Open Source Software 9, 6260 (2024).

[1] University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland
[2] Earth Observation of Agroecosystems Team, Division Agroecology and Environment, Agroscope, Reckenholzstrasse 191, CH-8042 Zürich, Switzerland

Contact information and more on other projects in the eoa-team

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
Agroscope

Agroscope Swiss centre of excellence for agricultural research